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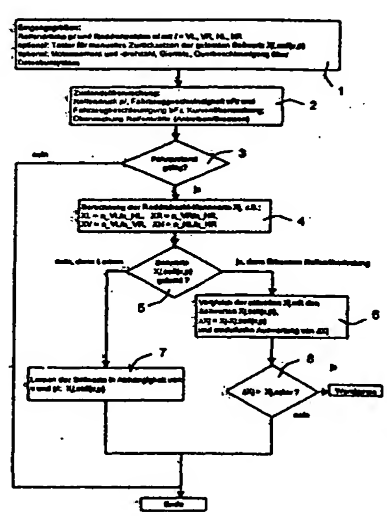
[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD FOR DETERMINING THE LOAD EXERTED ON A VEHICLE TIRE

(54) Bezeichnung: VERFAHREN ZUR BESTIMMUNG DER BELASTUNG EINES FAHRZEUGREIFENS



1 INPUT VARIABLES:
TIRE PRESSURES pi AND WHEEL SPEEDS ni WITH i = VL, VR, HL, HR
OPTIONAL: SENSOR FOR MANUAL RESETTING OF LEARNED SET VALUES xj,soll(v,p)
OPTIONAL: ENGINE TORQUE AND SPEED, YAWING RATE, TRANSVERSAL ACCELERATION VIA DATA BUS SYSTEM

2 STATE MONITORING:
TIRE PRESSURE pi, VEHICLE SPEED VFZ AND VEHICLE ACCELERATION BFZ,
CURVE MONITORING;
MONITORING TIRE FORCES (DRIVING/BRAKING)

3 VEHICLE STATE VALID?
JA = YES
NEIN = NO

4 CALCULATING WHEEL SPEED PARAMETERS XJ, E.G:
XL = n_VL/n_HL, XR= n_VR/n_HR,
XV = n_VL/n_VR, XH = n_HL/n_HR

NO, THEN LEARN
YES, THEN DETECT TIRE OVERLOAD

5 SET VALUES xj,soll(v,p) LEARNED?

6 COMPARE CURRENT XJ WITH SET VALUES xj,soll(v,p),
ΔXj = xj-xj,soll(v,p)
AND STATISTICAL EVALUATION OF ΔXj

7 LEARN SET VALUES DEPENDING ON v AND pi: xj,soll(v,p)
ja = YES
NEIN = NO

8 ΔXj > XJ, SCHW? WARNING LIGHT
END

(57) Abstract: The invention relates to a method for determining the charge or load exerted on a tire of a motor vehicle and/or for monitoring tire pressure, wherein the pressure (pi) in each tire is detected during operation of the vehicle and the rotational behavior of the individual wheels (ni) is observed. Load distribution parameters are also determined by comparing the rotational behavior and/or changes in said rotational behavior of the individual wheels during given driving states taking into account preset and/or predetermined and/or learned variables. Tire pressure (pi) and load distribution parameters (Xj) are used to determine the load or charge exerted on the tires and/or pressure loss.

[Fortsetzung auf der nächsten Seite]

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Method of determining the load on a vehicle tyre

The invention relates to a method of determining the capacity utilisation or load of the tyre of a motor vehicle and/or for monitoring the tyre pressure.

An existing approach used in motor vehicles is to determine the tyre pressure or a variable representing the drop in tyre pressure by means of pressure-measuring systems operating on the basis of pressure sensors (TPMS = Tyre Pressure Measuring System) or, if not using pressure sensors, by means of systems based on wheel rotation speed (DDS = Deflation Detecting System).

In the case of the so-called TPMS system, the measured pressure and the temperature are detected by sensors disposed in the tyre and are wirelessly transmitted to a receiver mounted in the vehicle. The pressure data is evaluated in a control system and the pressure prevailing in the individual tyres is determined.

Safety and vehicle control systems used as standard, such as ABS, ASR, ESP, DDS, etc., need to have a relatively accurate knowledge of the rotational behaviour of individual vehicle wheels as a matter of course. Nowadays, vehicles are therefore equipped with passive or active wheel speed sensors, which supply the input signals needed for the various safety and control systems. In the case of the DDS (Deflation Detecting System), for example, tyre pressure, which can not be derived directly from the wheel speeds, can be obtained from the dynamic rolling circumference of the individual vehicle wheels. The load dependency of the dynamic rolling circumference tends to be regarded as a fault-indicating

variable in pressure loss detection systems operating with the aid of the DDS.

To date, there is no known method of measuring, during operation of the vehicle, i.e. during travel, the tyre utilisation capacity, which is determined on the basis of the actual tyre pressure as well as the wheel load or wheel load distribution amongst other things. It is not enough to monitor loss of tyre pressure because the capacity utilisation or load on the tyre is responsible for the safety and serviceability of the tyre, even more so than tyre pressure, and because different tyre pressures are needed to produce comfortable driving behaviour and ideal capacity utilisation of the tyre depending on wheel load or wheel load distribution.

Accordingly, the underlying objective of the present invention is to propose a method that will enable the capacity utilisation or load of a tyre to be detected under different conditions, in particular at differing wheel loads or wheel load distributions.

Such a method will make it possible to eliminate overload of the tyre, guarantee the durability of the tyre and improve the general safety of vehicle and driver.

It has been discovered that the objective described above can be achieved by means of the method specified in claim 1, the characterising features of which are as follows:

- during operation of the vehicle, the pressure in the individual tyres is detected and
- the rotational behaviour of the individual wheels is observed and
- load distribution characteristic variables of the tyres are determined by comparing the rotational behaviour

and/or changes in the rotational behaviour of the individual wheels in specific driving states taking account of pre-set and/or learned variables and

- finally, the tyre pressure and the load distribution characteristic variables are used to draw conclusions about the capacity utilisation or load of the tyres and/or about pressure loss.

The invention is based on the knowledge that the variable which affects the safety and service life of a tyre to a large degree, namely the capacity utilisation of the tyre, can be determined by measuring pressure and observing the wheel rotational behaviour. From development work done on pressure-monitoring systems based on wheel rotation speed (DDS), it is known that the dynamic rolling circumference is dependent on tyre pressure and wheel load. Since the tyre pressure is known - measured by TPMS for example - comparing the rotation speeds of the different vehicle wheels and evaluating any variances will enable characteristic variables to be determined which will represent the capacity utilisation of the tyres.

In one example of an embodiment of the invention, a pressure-measuring system based on the use of pressure sensors (such as TPMS = Tyre Pressure Measuring System), is used to determine the tyre pressure, whilst characteristic variables representing the load distribution are determined using a system based on an evaluation of wheel speed data operating in the manner of a system (DDS) used to determine conditions relating to the dynamic rolling circumferences of the individual tyres. Consequently, the function of detecting capacity utilisation can be set up using existing systems.

In another advantageous embodiment of the invention of a different type, the number of revolutions of a front wheel is

compared with the number of revolutions of a rear wheel at the same vehicle speed or at approximately the same vehicle speed (e.g. vehicle reference speed), evaluated to obtain a load distribution characteristic variable and the value and/or the change in the load distribution characteristic variables in defined driving situations is/are used as a means of calculating the capacity utilisation or load of the tyres and/or the pressure loss.

In determining the load distribution characteristic variables, it has proved to be of practical effect to generate a quotient from the front wheel and the rear wheel speed of the wheels (or the corresponding number of revolutions) respectively on the same vehicle side and to evaluate the value and/or the changes in the load distribution characteristic variables at (approximately) the same vehicle speed or to take account of the vehicle speed. Suitable variables for determining the load distribution are the quotients V_{VL}/V_{HL} or V_{VR}/V_{HR}, which can also be correlated with one another in order to enhance the "reliability" and accuracy of the detection system. Other types of correlation, e.g. the diagonals or corresponding functional correlations of other types, such as quotients of speed sums in particular, may also be used; this will depend on the respective design and layout of the vehicles and the monitoring systems.

Another proposed feature is that in order to detect relative changes in load distribution perpendicular to the direction of travel - caused by a passenger getting in for example - the speeds of the wheels of one axle are respectively compared and evaluated.

In order to increase the measuring and evaluation accuracy, it is also possible and in effect preferable to use the

revolution times of the wheels instead of the wheel rotation speeds or wheel speeds as the basis for the calculations.

The desired values or standard values representing the load distribution characteristic variables for a specific capacity utilisation or load, e.g. part-load or full load, can be input manually or the system can be configured so that the corresponding desired or standard values are automatically detected as soon as specific pre-set conditions are met.

It has also been found to be of practical advantage to determine values applicable to part-load operation for the load distribution characteristic variables in defined driving situations, e.g. with (at least almost) free-rolling wheels, during constant travel in a straight line, etc., or to incorporate the driving torque in the calculations on the basis of statistical observations or by evaluating criteria relating to a part-load operation. Although characteristic variables obtained for driving under free-rolling conditions are generally more accurate and are therefore evaluated by preference, in practical terms, given that the amount of available data is limited, it is often expedient to incorporate data pertaining to driving under non-free-rolling conditions as well. In situations of the latter type, the effect which the respective driving parameter has on the characteristic variable must be eliminated from the resultant data.

The information needed to determine the driving situation is preferably obtained from an ABS or ESP system of a type known per se.

For the purposes of the invention, the instant at which a standard state, i.e. a defined state or desired state,

prevails can be fixed manually or a start signal automatically triggered, e.g. once a predetermined air pressure and load state is assumed. After a tyre change or after initial assembly, it is not always possible to initiate a reset procedure or a start signal manually in many instances.

In another type of embodiment of the method proposed by the invention, values for the load distribution characteristic variables and the associated tyre pressure values are learned and stored during pre-set vehicle states. These learned characteristic variables may be also be specifically determined depending on a vehicle parameter, for example as a function of speed. In the latter case, it particularly expedient to establish consecutive periods for the driving parameter and determine a learned value for every period.

Learning processes are preferably also used for the system which operates on the basis of evaluating wheel speed data. More specifically, during the learning phase, the desired or standard state is learned, in particular by detecting and storing variables representing the rolling circumference of the wheels. The variables representing the rolling circumference of the wheels may also be proportional variables of different wheel pairs. Depending on the application, the proportional variables may naturally also be determined by different types of calculation or by a different type of comparison of the individual wheels.

In another preferred embodiment of the invention, after the learning phase, the system based on evaluating wheel speed data detects changes in the variables representing the rolling circumference of the wheels by comparing instantaneous characteristic variables representing the rolling circumference of the wheels with learned variables

representative of the rolling circumference of the wheels. The difference between the learned variable and the instantaneous variable in this case is a measure of the wheel load.

Very little effort is needed to extend the system based on evaluating the wheel speed information to a full DDS, i.e. a system which is in a position to detect a tyre pressure loss, independently of the pressure measuring system (TPMS). This system also enables a comparison and evaluation to be run between the tyre pressure loss determined by the pressure sensors (TPMS) and the tyre pressure loss determined by the DDS system. If the tyre pressure loss determined on the basis of wheel speed data is higher, by a specific amount, than the tyre pressure loss ascertained on the basis of the pressure sensors, this can be imputed to flexing induced by an increase in the wheel load.

Other features, advantages and Optional applications of the invention will be explained in more detail with reference to the appended drawings. Of these:

Fig. 1 is a schematic illustration showing a sequence diagram outlining the basic principle of one example of an embodiment of the method proposed by the invention,

Fig. 2 is a diagram illustrating the dependency of the load distribution characteristic variable on payload,

Fig. 3 is a diagram similar to that of Fig. 2 intended to illustrate detection of the part-load state and

Fig. 4 gives several diagrams illustrating the principle behind process of detecting capacity utilisation in

the example of a vehicle with a payload which essentially places load on the rear axle.

Figure 1 is intended to illustrate how the method proposed by the invention operates. The method is based on evaluating the individual tyre pressure p_i (index i = 1...4 denoting the respective wheel) and the rotational behaviour or wheel speeds VL, VR, HL and HR as input variables for a system used to implement the method proposed by the invention. This is symbolised by block 1.

In the embodiment described as an example here, the instantaneous state of the tyre (pressure), the wheels (rotational behaviour) and the vehicle (acceleration, driving situation, etc.) and changes in these variables are detected and monitored in block 2.

After "querying" the current vehicle state in step 3, wheel speed characteristic values are calculated as indicated (in this example wheel revolutions "n" are compared with one another instead of wheel speeds "v") and then checked at 5.

The process of learning the desired values is continued (symbolised by 7) or, if a tyre overload was detected (alternative "yes" on branch 5) by comparing the instantaneous values with the desired values in operator 6 causing a drop below a pre-set threshold (branch 8), an alarm function is triggered or a warning lamp switched on.

The individual procedures and decisions during the sequence of the method proposed by the invention are specified in Fig. 1 in steps 1-8 listed above.

Fig. 2 is a graph plotting changes in or the dependency of

characteristic variables XL, XR on payload (payload L at the rear); this particular example relates to a vehicle in which the payload increases the load on the rear axle.

The revolutions or speeds of the wheels on a respective side of the vehicle are used to determine the load distribution characteristic variables XL and XR. Accordingly, it may be said that:

$$XL - V_{VL}/V_{VL} \qquad \text{and} \qquad XR = V_{VR}/V_{HR}.$$

The characteristic curve XL, XR = f (payload L at the rear) shown in Fig. 2 is applicable at a constant vehicle speed v and constant pressure in the individual tyres. L_{min} is the load state with the minimum possible load (driver only with no additional load) and L_{max} the load state with effect from which an alarm indicator will be triggered.

Fig. 3 is intended to illustrate the processes by which the characteristic variables XL and XR are learned with respect to the minimum load state of a vehicle that is essentially loaded at the rear. The load distribution characteristic variables XL_t, XR_t, XV_t and XH_t are detected at different instants together with the associated pressure values, stored and statistically evaluated. It is assumed that the state at part-load or minimum load will occur on a repeated basis during operation of a vehicle, for which reason the value of the corresponding load distribution characteristic variable is detected by a process of statistical evaluation or by inference.

In the example illustrated here, characteristic variables XL_t, XR_t, XV_t and XH_t are detected respectively for every period of ignition of the vehicle (time between starting the engine and switching the engine off). In addition to the characteristic

variables, the associated tyre pressure p_i is also stored in each case. To simplify matters, it is assumed that the vehicle is also operated without load (driver only with no additional load) during several periods of ignition and a desired value $X_{desired}$ may be defined from the values X_t in a particularly simple manner on the basis of maximum function.

Fig. 4 provides an explanation of the load detection system and the corresponding load distribution characteristic variables in different situations and at a differing tyre pressure. The respective peripheral conditions which apply are illustrated in Fig. 4.

In the part-diagram labelled a) in Fig. 4, a detection threshold $X_{thresh,desired}$ is provided, which can initially remain uncompensated because the tyre pressure of all wheels corresponds to the desired pressure to the requisite degree of accuracy. If the detection threshold is exceeded, the system will generate a warning. The part-diagrams labelled b) illustrate situations in which one or more wheels has a lower pressure $\Delta p<0$. Given that a wheel with a lower pressure can no longer take as great a load as a wheel which is at the desired pressure, the detection threshold must be compensated down to lower values depending on pressure, producing $X_{thresh,\ comp}$. In this situation, it is expedient to make the adjustment on the basis of the lowest pressure on each vehicle side. As a result, the capacity utilisation warning indicating too high a capacity utilisation is already activated at a lower load In situations 2 and 3 illustrated here, the tyre pressures of the wheels used to determine X are at variance with one another and it is therefore also necessary to compensate $X_{desired}$ resulting in $X_{desired,comp}$.

The pressure-dependent process of compensating the detection

thresholds will depend on what type of tyre is used. It has been found that a compensation can be applied with sufficient accuracy by using constants dependent on vehicle type as a preference. This is possible because, in terms of vehicle operation as a rule, it is standard practice to permit the use of specific types of tyres only on a specific type of vehicle.

The major disadvantage of a method based on pressure measurement (TPMS) is that the only information which can be made available to the driver is that relating to pressure. However, the extent to which the tyre is subjected to load does not depend on pressure alone but is also affected by the instantaneous load, which is unknown. The driver must therefore continue to assume responsibility for ensuring that the correct air pressure is used for the associated load. In practice, it is often possible to draw conclusions about overload on tyres from the temperature measurements simultaneously taken by the TPMS sensor. However, the temperature in the sensor on the rim is susceptible to numerous interference factors. These measurements do not therefore reflect the temperature load of the tyre (at the critical positions) to a sufficient degree of accuracy.

As a result of its mounting, the disadvantage of a DDS is that the absolute tyre pressure is unknown. It has an advantage, however, in that a change in rolling circumference induced by a change in the flexing of a tyre can be detected. This flexing of the tyre is a decisive measure of the load placed on the tyre. In practice, a DDS system is not able to differentiate between a change in flexing induced by a change in air pressure or a change in wheel load. Consequently, the main interference factor inherent in a tyre pressure control system using DDS is the load.

The method proposed by the invention overcomes both the disadvantages of a known TPMS and the shortcomings of a DDS. The method proposed by the invention is based on a combination of a measuring method based on pressure sensors and a method based on observation and evaluation of the wheel speeds, the physical principles of which are based on the dynamic rolling circumferences of the individual tyres and the relative changes in these rolling circumferences when changes occur in the wheel load.

The air pressure detected by the pressure sensors is exact. The capacity utilisation of the tyre is monitored by means of the wheel rotational behaviour on the basis of variations in pressure and load. This combination therefore offers the possibility of determining the tyre load distribution. Accordingly, the driver can largely be relieved of responsibility for the tyres. Compared with a pressure measuring system based solely on pressure sensors, such as a TPMS, the solution proposed by the invention has an additional advantage in that the system is able to adapt to variations in load automatically, i.e. the driver does not have to indicate to the TPMS that a new desired value for pressure must now be applied as a function of load.

In a similar manner, the method proposed by the invention uses functions and detection systems forming part of pressure loss detection processes which operate on the basis of data from wheel speed sensors.

The "standard state", i.e. air pressure correctly adjusted for the load state (ascertained via the TPMS) at any one time, can be entered in the system by the driver operating a push-button, for example, or, as illustrated in Fig. 3, by means of a maximum function without any input on the part of the

driver. As with the DDS, the rolling circumferences are initially detected during a learning phase. After the learning phase, the actual state is then compared with the learned state. This comparison supplies information about increased flexing and/or capacity utilisation of the tyre; in certain respects, the computational procedure is similar to that involved in detecting a pressure loss via DDS. The decision to issue the driver with a warning that the tyre is overloaded is taken on the basis of the combined evaluation of instantaneous tyre pressure and flexing.

The invention incorporates a method of determining or monitoring the tyre load distribution on the basis of a combination of a tyre air pressure control system (TPMS) taking direct measurements and a system which observes the wheel rotational behaviour and the tyre rolling circumferences in the same way as DDS.

The method is preferably operated in a motor vehicle, in particular a passenger vehicle.

Claims:

1. Method of determining the capacity utilisation or load of the tyre of a motor vehicle and/or monitoring the tyre pressure,
characterised in that
- during operation of the vehicle, the pressure in the individual tyres is detected and
- the rotational behaviour of the individual wheels is observed and
- load distribution characteristic variables of the tyres are determined by comparing the rotational behaviour and/or changes in the rotational behaviour of the individual wheels in specific driving states taking account of pre-set and/or learned variables and
- finally, the tyre pressure and the load distribution characteristic variables are used to draw conclusions about the capacity utilisation or load of the tyres and/or about pressure loss.

2. Method as claimed in claim 1, **characterised in that** a pressure-measuring system based on the use of pressure sensors (TPMS) is used to determine the tyre pressure, whilst characteristic variables representing the load distribution are determined using a system based on an evaluation of wheel speed data operating in the manner of a system (DDS) for determining conditions relating to the dynamic rolling circumferences of the individual tyres.

3. Method as claimed in claim 1 or 2, **characterised in that** the number of revolutions of a front wheel is compared with the number of revolutions of a rear wheel at the same vehicle speed or at approximately the same vehicle speed and evaluated in order to produce a load

distribution characteristic variable and the value and/or the change in the load distribution characteristic variables in defined driving situations is used as a means of calculating the capacity utilisation or load of the tyres and/or the pressure loss.

4. Method as claimed in claim 3, **characterised in that** in order to determine the load distribution characteristic variables, a quotient is obtained from the front wheel and the rear wheel speed of the wheels respectively on the same vehicle side (V_{VL}/V_{HL}; V_{VR}/V_{HR}) and the value and/or the changes in the load distribution characteristic variables are evaluated at (approximately) the same vehicle speed or taking account of the vehicle speed.

5. Method as claimed in claim 4, **characterised in that** in order to detect relative changes in load distribution perpendicular to the direction of travel, the speeds of the wheels of one axle (V_{VL}/V_{HL}; V_{VR}/V_{HR}) are respectively compared and evaluated.

6. Method as claimed in claim 4, **characterised in that** the speed and/or tyre pressure torque and/or wheel torque are taken into account as a driving parameter.

7. Method as claimed in one of claims 4 to 6, **characterised in that** the desired values or standard values representing the load distribution characteristic variables for a specific capacity utilisation or load, e.g. part-load or full load, can be input manually or the system can be configured so that the corresponding desired or standard values are automatically detected as soon as specific pre-set conditions are met.

8. Method as claimed in one or more of claims 1 to 7, **characterised in that** values applicable to part-load operation are determined for the load distribution characteristic variables in defined driving situations, e.g. with at least almost free-rolling wheels, or the driving torque is taken into account in the calculations on the basis of statistical observations or by evaluating criteria relating to part-load operation.

9. Method as claimed in at least one of claims 1 to 8, **characterised in that** the instant at which a standard state, i.e. a defined state or desired state, prevails is fixed manually or a start signal automatically triggered, e.g. once a predetermined air pressure and load state is assumed.

10. Method as claimed in at least one of claims 4 to 9, **characterised in that** values for the load distribution characteristic variables and the associated tyre pressure values are learned and stored during pre-set vehicle states, such as straight driving, free-rolling wheels, etc.

11. Method as claimed in claim 2, **characterised in that** during a learning phase, the system based on evaluating wheel speed data learns the desired or standard state, in particular by detecting and storing variables representing the rolling circumference of the wheels.

12. Method as claimed in claim 11, **characterised in that** the variables representing the rolling circumference of the wheels may also be proportional variables of different wheel pairs.

13. Method as claimed in claim 11 or 12, **characterised in that**, after the learning phase, the system based on evaluating wheel speed data detects changes in the variables representing the rolling circumference of the wheels by comparing instantaneous characteristic variables representing the rolling circumference of the wheels with learned variables representative of the rolling circumference of the wheels.

14. Method as claimed in claim 13, **characterised in that** the difference between the learned variable and the instantaneous variable is a measure of the wheel load.

15. Method as claimed in claim 2, **characterised in that** the system based on evaluating the wheel speed data can be extended to obtain a full DDS, which detects tyre pressure loss independently of the pressure measuring system (TPMS).

16. Method as claimed in claim 15, **characterised in that** a comparison is run between the tyre pressure loss determined by the pressure sensors (TPMS) and the tyre pressure loss determined by the DDS system and the result evaluated.

17. Method as claimed in claim 15 or 16, **characterised in that** if the tyre pressure loss determined on the basis of wheel speed data is higher, by a specific amount, than the tyre pressure loss ascertained on the basis of the pressure sensors (TPMS), this can be imputed to flexing induced by an increase in the wheel load.

Fig. 1

1 Input variables:

Tyre pressures *pi* and wheel speeds n*i* where *i* = VL, VR, HL, HR

Optional: button for manual re-setting of learned desired values *Xj,desired*(v, p)

Optional: engine torque and speed, yaw rate, transverse acceleration via data bus system

2 State monitoring:

Tyre pressure pi, vehicle speed v*Fz* and vehicle acceleration b*Fz*, curve monitoring: monitoring of tyre forces (drive/braking)

no

3 Vehicle state valid?

yes

4 Computation of the wheel speed characteristic values Xj, e.g.:

XL = n_VL/n_HL, XR = n_VR/n_HR,

XV = n_VL/n_VR, XH = n_HL/n_HR

5 Desired values *Xj.desired*(v, p) learned?

no, move to learning — yes, followed by tyre overload detection

6 Comparison of instantaneous Xj with the desired values Xj,desired(v, p),

ΔXj = Xj-Xj,desired(v,p)

and statistical evaluation of ΔXj

7 Learning desired values depending on v and pi: *Xj,desired*(v, p)

8 ΔXj > Xj,thresh? yes warning lamp

no

End

Fig. 2

for v = const., pi = constant

Overload

Payload L at the rear

Fig. 3

XL or XR

for v = const., pi = constant

Payload L at the rear

Fig. 4

a) Tyre pressures correspond to desired state

$X_{desired}$ $X_{thresh,desired}$

Payload L at the rear L^* : permissible payload

b) Tyre pressures at variance with desired state

Case 1: $p_{vr} - p_{desired} = \Delta p$ and $p_{HR} - p_{desired} = \Delta p$ where $\Delta p<0$

$X_{desired,comp} = X_{desired}$

$X_{thresh,comp}$ $X_{thresh,desired}$

L_{min} L^*_{inst} $L^*_{desired}$

Payload L at the rear

Case 2: $p_{vr} = p_{desired}$ and $p_{HR} - p_{desired} = \Delta p$ where $\Delta p<0$

$X_{desired,comp}$ $X_{thresh,comp}$ $X_{thresh,desired}$

L_{min} L^*_{inst} $L^*_{desired}$

Payload L at the rear

Case 3: $p_{vr} - p_{desired} = \Delta p$ and $p_{HR} - p_{desired} = \Delta p >0$

$X_{desired,comp}$ $X_{thresh,comp}$ $X_{thresh,desired}$

L_{min} L^*_{inst} $L^*_{desired}$

Payload L at the rear

Case 4: $p_{vr} - p_{desired} = \Delta p$ and $p_{HR} - p_{desired} = \Delta p$ where $\Delta p >0$

$X_{desired,comp} = X_{desired}$

$X_{thresh,comp}$ $X_{thresh,desired}$

L_{min} L^*_{inst} $L^*_{desired}$

Payload L at the rear

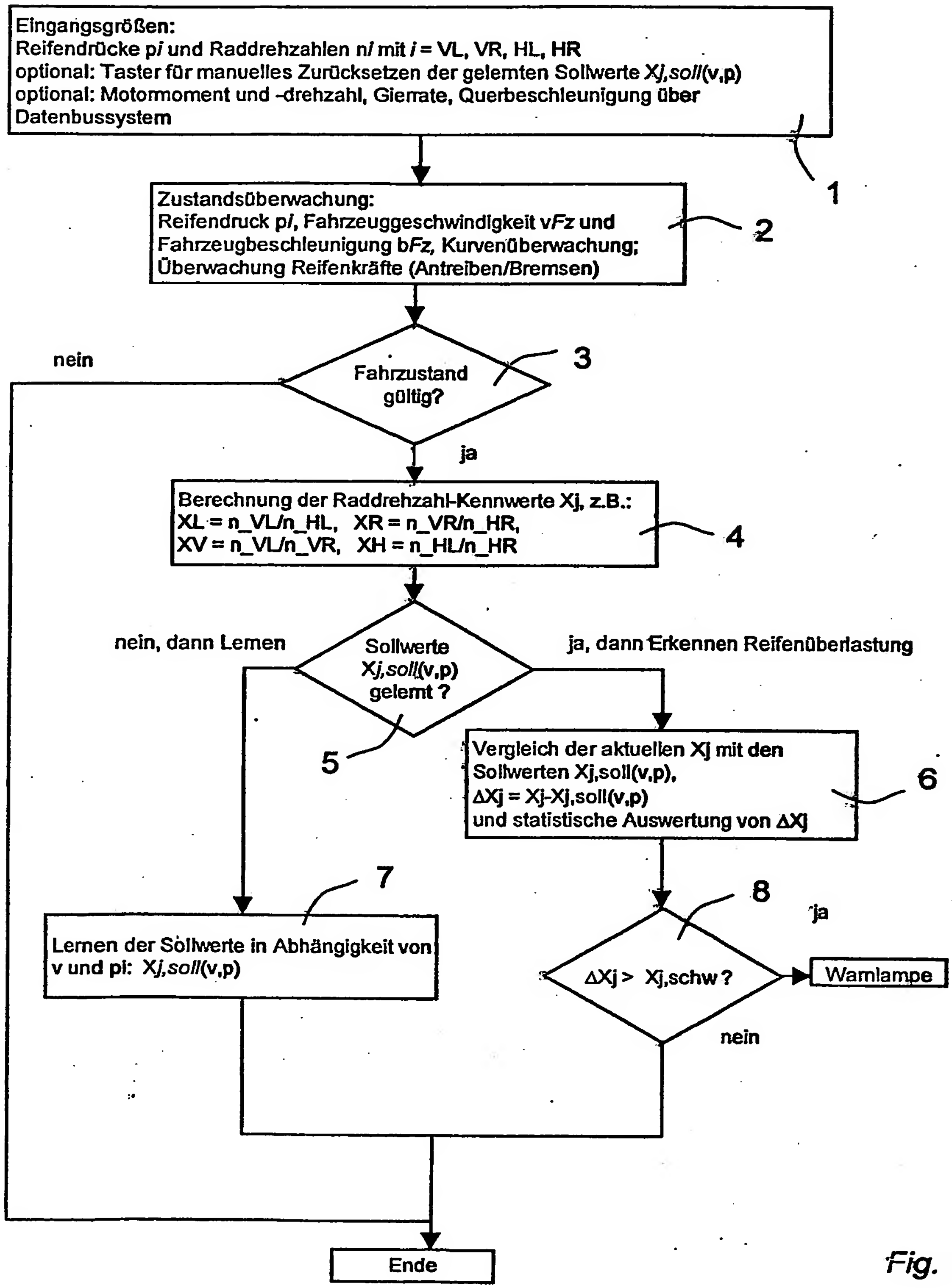
Eingangsgrößen:
Reifendrücke pi und Raddrehzahlen ni mit i = VL, VR, HL, HR
optional: Taster für manuelles Zurücksetzen der gelernten Sollwerte Xj,soll(v,p)
optional: Motormoment und -drehzahl, Gierrate, Querbeschleunigung über Datenbussystem
1
Zustandsüberwachung:
Reifendruck pi, Fahrzeuggeschwindigkeit vFz und Fahrzeugbeschleunigung bFz, Kurvenüberwachung;
Überwachung Reifenkräfte (Antreiben/Bremsen)
2
nein
Fahrzustand gültig?
3
ja
Berechnung der Raddrehzahl-Kennwerte Xj, z.B.:
XL = n_VL/n_HL, XR = n_VR/n_HR,
XV = n_VL/n_VR, XH = n_HL/n_HR
4
nein, dann Lernen
Sollwerte Xj,soll(v,p) gelernt ?
ja, dann Erkennen Reifenüberlastung
5
Vergleich der aktuellen Xj mit den Sollwerten Xj,soll(v,p),
ΔXj = Xj-Xj,soll(v,p)
und statistische Auswertung von ΔXj
6
7
8
ja
Lernen der Sollwerte in Abhängigkeit von v und pi: Xj,soll(v,p)
ΔXj > Xj,schw ?
Warnlampe
nein
Ende

Fig. 1

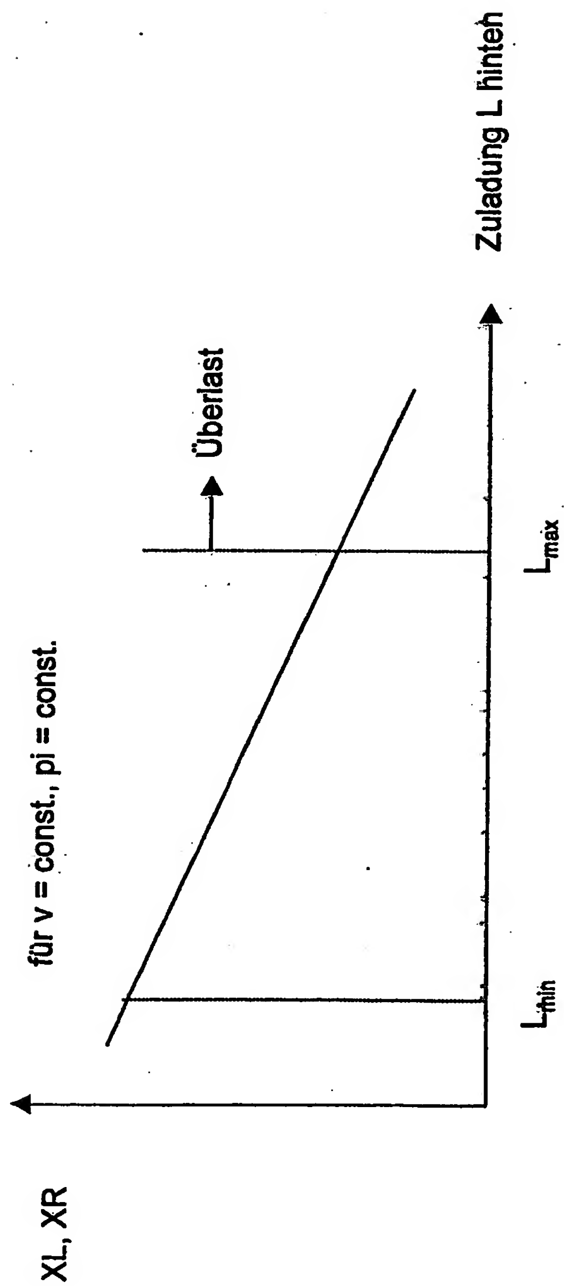
Zuladung L hinten
Überlast
für v = const., pi = const.
L_{max}
L_{min}
XL, XR

Fig. 2

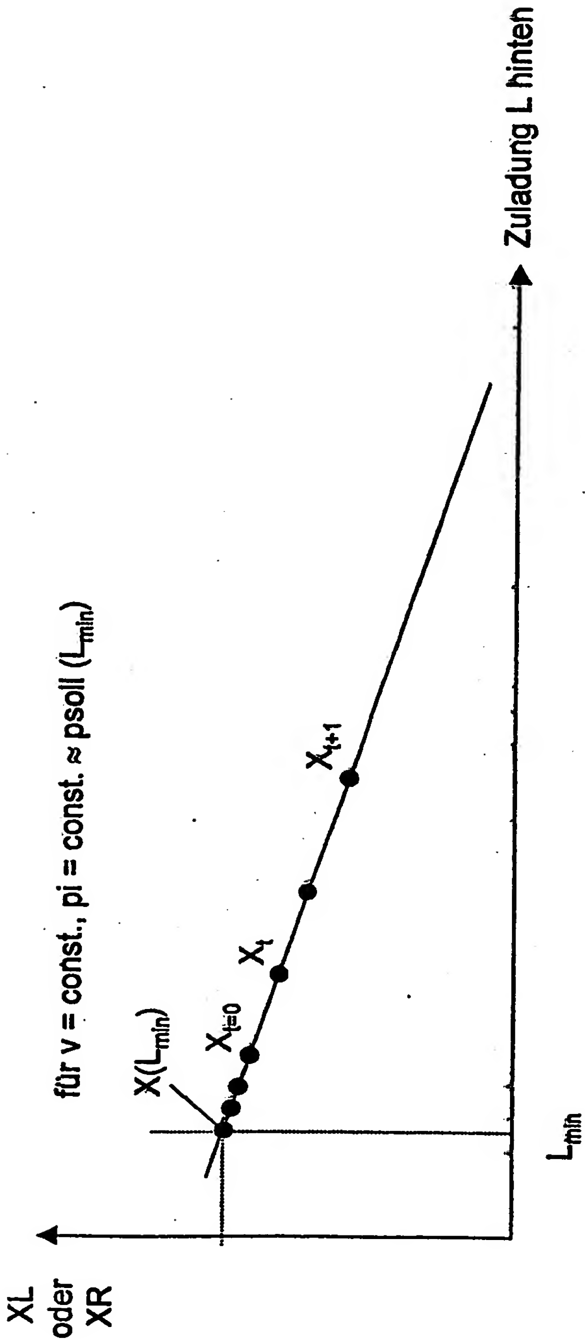
für v = const., pi = const. ≈ psoll (L_{min})
Zuladung L hinten
XL oder XR
$X(L_{min})$
$X_{t=0}$
X_t
X_{t+1}
L_{min}

Fig. 3

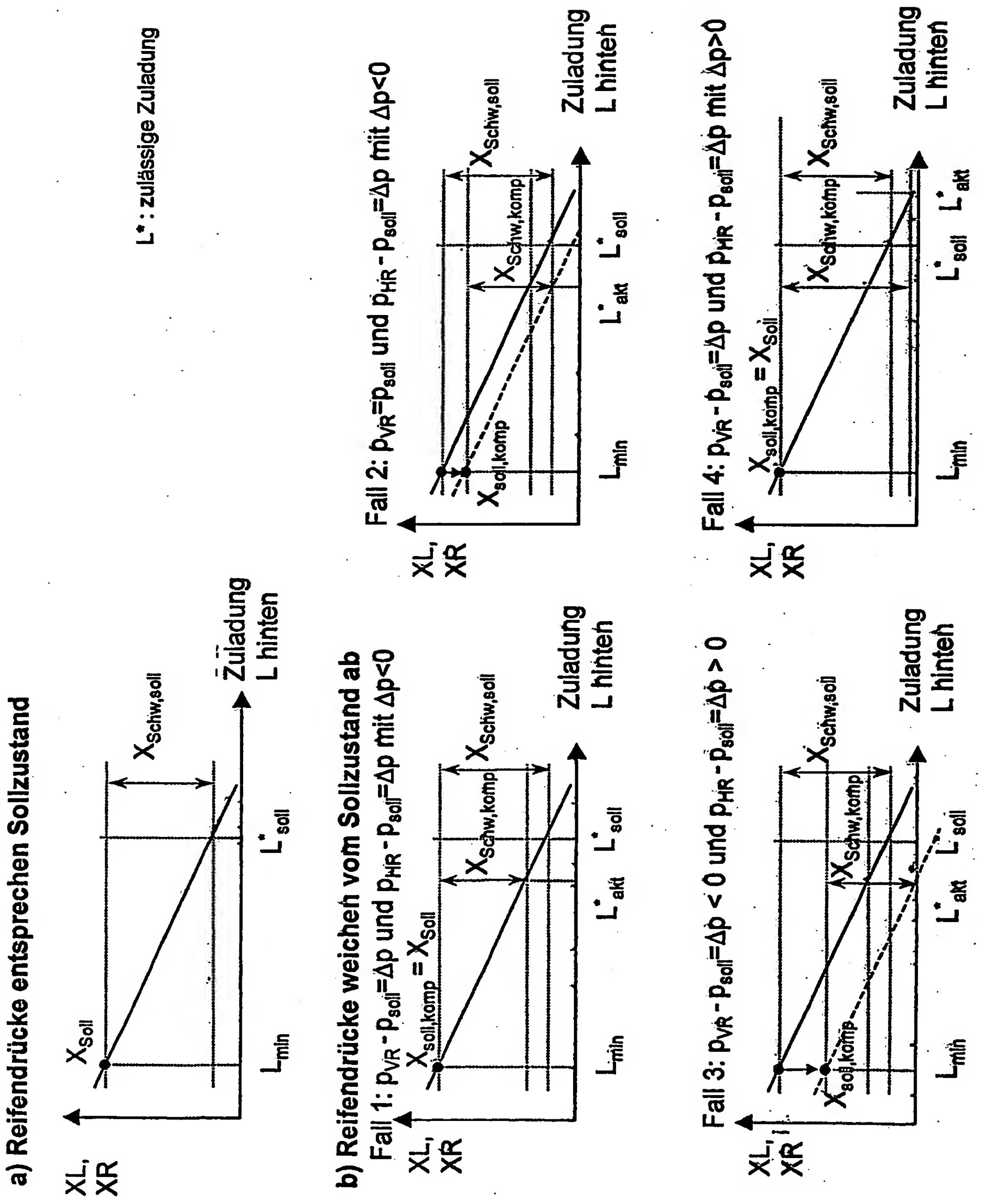
L*: zulässige Zuladung
a) Reifendrücke entsprechen Sollzustand
XL, XR
X_{Soll}
$X_{Schw,soll}$
Zuladung L hinten
L_{min}
L^*_{soll}
b) Reifendrücke weichen vom Sollzustand ab
Fall 1: $p_{VR} - p_{soll} = \Delta p$ und $p_{HR} - p_{soll} = \Delta p$ mit $\Delta p < 0$
$X_{soll,komp} = X_{Soll}$
$X_{Schw,komp}$
L^*_{akt}
Fall 2: $p_{VR} = p_{soll}$ und $p_{HR} - p_{soll} = \Delta p$ mit $\Delta p < 0$
$X_{soll,komp}$
Fall 3: $p_{VR} - p_{soll} = \Delta p < 0$ und $p_{HR} - p_{soll} = \Delta p > 0$
Fall 4: $p_{VR} - p_{soll} = \Delta p$ und $p_{HR} - p_{soll} = \Delta p$ mit $\Delta p > 0$

Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/08478

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60T8/00 B60C23/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60T B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 198 07 880 A (DAIMLER CHRYSLER AG) 9 September 1999 (1999-09-09) the whole document	1-8, 10-13
Y		9,15,16
X	EP 0 719 663 A (TOYOTA MOTOR CO LTD ;TOYODA CHUO KENKYUSHO KK (JP)) 3 July 1996 (1996-07-03) page 13, line 16 -page 13, line 59	1,3-6
P,X	DE 100 58 099 A (CONTINENTAL TEVES AG & CO OHG) 23 May 2002 (2002-05-23) column 2, line 4 -column 3, line 54	1,2
Y	DE 196 11 364 A (DAIMLER BENZ AG) 2 October 1997 (1997-10-02) column 3, line 11 -column 2, line 61	9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 December 2002	16/12/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Marx, W

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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